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Designing personalised instruction: A research and design framework

Natalia Kucirkova[1,2] | **Libby Gerard**[3] | **Marcia C. Linn**[3]

[1]Norwegian Centre for Learning Environment and Behavioural Research, University of Stavanger, Stavanger, Norway

[2]Faculty of Wellbeing, Education & Language Studies, the Open University, Milton Keynes, UK

[3]University of California-Berkeley, Graduate School of Education, Way, Berkeley, CA, USA

Correspondence
Natalia Kucirkova, Norwegian Centre for Learning Environment and Behavioural Research, University of Stavanger, NO-4036 Stavanger, Norway.
Email: Natalia.kucirkova@uis.no

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Abstract

Advances in technology have increased the opportunities for designers to personalise instruction based on student actions. We conducted semi-structured interviews with an international sample of educational professionals including researchers, teachers and designers, and reviewed interdisciplinary literature on personalisation to propose a framework for personalisation research and design. Thematic analysis of the interviews revealed that professionals value each type of personalisation opportunity (eg, customising for age-appropriate content, supports for student choice, automated guidance based on learner responses) and identify challenges (eg, trade-offs between adaptive and standardised instruction). Three research/design dilemmas emerged: individualisation and equity; group customisation and individual benefit; and adaptation and validity of measurement. We discuss these dilemmas in relation to three categories of personalisation: *customisation* by designers or teachers to support a specific audience (grade level, course, community); *individualisation* to support user choice (of book to read, project topic); and *adaptation* of instructional activities based on automated analysis of logged user performance (performance metrics, natural language processing, cumulative

indicators). We suggest some guiding questions for a generative agenda for future research on personalised instruction.

KEYWORDS
customisation, design, individualisation, personalisation, technologies, theoretical framework

Practitioner notes

What is already known about this topic
- Personalised learning is popular among educational professionals.
- Personalised design has multiple and inconsistent definitions.
- A shared framework for personalised instruction would facilitate research and design.

What this paper adds
- A succinct but comprehensive definition of personalised education.
- Perspectives on personalisation from an international group of practitioners and designers.
- A framework including three dilemmas to guide future research on the design and practice of personalised instruction.

Implications for practice and/or policy
- A shared definition of personalisation can support communication across diverse stakeholders.
- The framework can guide future design and instruction with personalised educational technology.
- The framework identifies dilemmas that illustrate ethical pathways for policymakers responsible for personalised education.

INTRODUCTION

Personalisation is a broad concept, encompassing diverse practices, products, and designs. To personalise learning technologies, educational professionals (individual researchers, designers, and teachers) capitalise on *personal* information about an individual, but they have operationalised personalisation in multiple ways. The term 'personalisation' is emphasised in several policy documents (eg, DfES, 2004), where it is used interchangeably with customisation, differentiated education, adaptive learning, individualised learning or one-to-one mentoring. This conceptual paper seeks to clarify the dimensions of personalisation as captured in the perspectives of educational professionals, contextualised by our own work in this area and located in the educational literature, to propose a joint framework that specifies the opportunities, challenges and tensions in personalised education. We take an interdisciplinary approach drawing on several disciplines of learning sciences, but mainly education, psychology and human-computer interaction studies, to offer a framework that gives voice to limitations, obstacles and dilemmas connected to personalised learning. This may help the field to critically examine personalisation technologies, prior to adopting and propagating them.

Our framework builds on previous frameworks and literature on personalised learning and education. In a recent systematic literature review, Shemshack and Spector (2020) established patterns in how the terms personalised, adaptive and individualised learning have been used in research and practice. Their terminology-based framework foregrounds adaptive and personalised learning in the use of research studies and individualised and customised learning in cooperative and business applications. Fitzgerald et al. (2018) classified diverse aspects of personalisation found in the literature concerned with technology-enhanced learning. Their emerging framework specified the dimensions of personalisation in technology-enhanced learning, including what is being personalised, what type of learning occurs when personalisation is used, which personal data are used to carry out various types of personalisation and who the agent, recipient and beneficiary of personalisation are. Adopting a psychology perspective, Tetzlaff et al. (2020) proposed a student model of personalised education, which focuses on the educational progress from student assessment to mastery of learning. Tetzlaff et al.'s (2020) cognitive learning framework specifies the instructional adaptations connected to different learner dynamics over different timescales. We propose a Framework of Personalised Instruction that is broader in scope and can serve as a basis for identifying the best practice in both research and design. We bring together usage scenarios, themes in published literature, factors we noticed in our own research and data from interviews with professionals familiar with personalised instruction.

While not exhaustive, our review of literature provides a summarised discussion of key issues in the field of personalised educational technology. This summary is defined by inclusion of the terms individualised, customised, adaptive and personalised learning as per FitzGerald et al. (2018)'s framework, and it includes a mention of some less known aspects of personalised education that we identified in our own work with educational technology. Given that previous work identified differences between the perspectives of researchers and designers (R&D) on personalised educational technology (Kucirkova & Flewitt, 2020), and given the lack of a shared terminology on personalised learning (see, eg, Chrysafiadi & Virvou, 2015), we aimed to offer a framework that would integrate perspectives of researchers and designers with shared interdisciplinary dimensions. A shared framework could facilitate communication across those implementing personalised education and designers of educational technologies, who might both support and resist person-centred education. An integrated and nuanced understanding could also strengthen private and government investments in personalised learning programmes (see Rose & Ogas, 2018). Our proposed framework, thus, intends to offer impetus for a common understanding of what personalisation means in current research and practice of educational technology, with the aim of focusing and advancing the field of learning sciences.

Definition of key terms

Throughout the paper, we refer to three related yet distinct concepts: learning, education and instruction. Learning is understood as a process directed by the individual, while education involves an institution or system that facilitate/inhibit the learning process. Instruction refers to the engagement, completion or mastery of a specific learning task, while education has a more holistic and encompassing goal. As the leading educational theorist, Jerome Bruner wrote, educators *instruct* students by supporting the students' growth and development, and instruction then is 'an effort to assist or to shape growth' (Bruner, 1966, p. 1). Educational and instructional interventions focus on students' engagement and motivation because the two 'provide the energy, direction, and skill set required to effectively tackle academic subject matter' (Martin, 2012, p. 303). To support students' motivation and engagement, personalised design can be adopted to an individual, through the mechanism of choice. Choice

can come in various forms, such as giving students several options that they can select in a game, or more broadly, giving students voice within an established framework (see Falk & Dierking, 2002).

Personalisation in the literature

We summarise key studies published between 2000 and 2020 in the areas of personalisation and educational technology that we selected from an interdisciplinary perspective to highlight the current state of knowledge in the field.

Personalisation as customisation for the audience

In our work, we refer to personalisation that involves tailoring instruction to the audience as customisation. Many researchers refer to customisation in terms of efforts that tailor content to individuals or groups of learners in order to capitalise on students' strengths (Waldeck, 2007), adjust to students' needs and feelings (Fuller, 1970), or incorporate parents' and children's agency in shaping their learning pathways (Gardner, 2009). Such personalisation has been defined more generally as an educational version of customisation of goods (Hargreaves, 2004), but also more specifically as the use of data for tailoring online courses and curriculum materials (Garrick et al., 2017).

Personalisation as individualisation supporting choice

The constructivist perspective foregrounds configurable learning experiences in student-centred contexts (see Peppler et al., 2016). Here a key reason for personalising education is to give learners choices in shaping their learning experiences, especially to align with their interests and prior cultural experiences. Providing choices that reflect student interests or backgrounds is framed as a mechanism for providing culturally relevant pedagogy (Hammond, 2015). When designing for choice, cultural differences need to be taken into account, as suggested by Kucirkova et al. (2020), whose study provides some tentative insights into possible cultural differences between the Japanese and British approach to personalised technologies. The authors suggest that in contrast to the ideal of an independent self that is promoted in Western cultures (eg, England), there is a greater resistance towards the individualisation aspect of personalisation in more collectivism-oriented cultures such as Japan. The possibility of choice endows learners with feelings of motivation and autonomy, which support their engagement in learning (eg, Matuk et al., 2020). Constructivist perspectives also emphasise supporting teachers to customise instruction to support student choice. King Chen et al., (2020) for example, supported teachers' choices in making changes and modifications to the curriculum, which in turn, motivated the students to learn.

From a socio-cultural perspective (eg, Ivey & Johnston, 2013), the circle of choice-motivation-learning engagement is part of a relational reciprocity, a way of increasing options for learners, teachers and the wider society (Gutierrez et al., 2019). For children and younger adults, the design of popular video games, web-based programs and resources incorporates choice to motivate users to engage with the programs on a repeated and sustained basis (eg, Hwang et al., 2012). Evidence is emerging that choice-based motivation could result in learning gains (Gerard, 2020; King Chen & Linn, 2019) although alternative findings exist (Kintsch, 2009).

Viewed from a socio-historical perspective, personalisation is engaging students, teachers or head teachers in shaping the collective learning process (Raynaud, 2017). This process is not issue-free. Empowering individuals with control over their educational setting could threaten the democratic ideal of equity by contributing to the privatisation of the education sector (Pykett, 2009; Robertson, 2005). In some societies, a neoliberal policy encourages educational reform through the growth of independent and private schools, while in other societies, the emphasis is on a free public education system for all, collaboration rather than competition, and formative assessments rather than summative scores for individual subjects (Paulsen et al., 2003).

Part of the personalised education rhetoric is students' motivation to engage with mobile and computer technologies in schools. Such use of personal mobile technologies has been studied mostly from an exploratory perspective (Haßler et al., 2016), with several observational studies documenting students' motivation to learn. Yet, as decades of psychological and educational research show, motivation and engagement are important but not sufficient prerequisites for learning to 'stick' and for students to remember and transform their knowledge (Brown et al., 2014). There are thus many nuances that need to be taken into account when considering personalised design and actual learning gains.

In leading models of motivation, personalisation is positioned as a separate variable from choice and contextualisation and all three variables feed into intrinsic motivation (Cordova & Lepper, 1996). Giving students choice is beneficial, but it needs to occur in constrained learning environments: for example, a choice of images from a pre-authored array in graphic design (Chin et al., 2019), or from six rather than 24 items in online search (Oulasvirta et al., 2009). In contrast, choice overload caused by too many choices, or a lack of knowledge about the choices, is confusing and as unhelpful as not providing any choices at all (Schwartz, 2004). Thus, pedagogical support for managing and understanding choices, especially in relation to the intensity of personalisation, matters for it to reap educational benefits.

Personalisation for adaptation to individuals

Advances in adaptive learning technologies have supported personalisation that monitors the student's progress and dynamically adjusts the content to the pace and pattern of each students' progress (Koedinger & Aleven, 2007). Such adaptation can maximise students' motivation to learn, particularly if students are offered content that it is neither too easy nor too difficult (eg, Lin et al., 2013). Adaptive personalised design is perceived as a key motivational technique and is frequently incorporated in e-learning (Wlodkowski & Ginsberg, 2017; Yannier et al., 2016). The use of children's data for automatically adapting the curriculum material, particularly with the use of artificial intelligence, raises new ethical challenges, which are outpacing technology advances (see, eg, Kay & Kummerfeld, 2019 for a comprehensive critique). Indeed, current adaptive learning presents several ethical (Williamson, 2019) and instructional challenges (Khosravi et al., 2020). Nevertheless, adaptive learning is perceived as superior to standard technology-mediated learning (Zhai et al., 2020).

An important consideration in relation to adaptation is the extent to which student characteristics can influence the benefits of adaptive learning. Providing students with guidance for written science explanations that is personalised to the students' level of knowledge integration is more effective for learning than generic guidance and as effective as guidance designed by teachers with limited time (Zhu et al., 2020). Further, when students know that the guidance was personalised to their explanation—as opposed to the same guidance given to all—they make greater revision gains (Liu et al., 2016). Thus, increased awareness of personalised adaptation can increase specific learning goals.

PERSONALISATION EXAMPLES

We illustrate the diverse uses of personalisation and its ambivalent role in educational technology use by drawing on our own work. We offer three examples that map on all three areas (customisation, individualisation and adaptation) of personalised education and that are relevant for science and reading instruction for the 4–11 age group.

An example of customisation involving interactive scientific models is when a teacher customises the Thermodynamics Challenge unit by adding a new activity to support student understanding of the variables they investigated in the previous activity. For individualisation, the Thermodynamics Challenge enables students to choose which investigation they would like to conduct in order to help a company determine which type of cup to purchase. Students are branched by the learning platform to an individualised pathway based on their choice. Both investigation branches are designed to provide students equal opportunities for learning thermal energy concepts. For adaptation, students are asked to explain why the experiments they selected are the most important ones for giving them evidence to write their report for the company.

A typical example of customisation in reading for pleasure is when teachers choose books based on the book's difficulty and when they match reader ability and text difficulty with the students' test scores. Individualisation happens when teachers recommend a book title for a child's reading based on the child's personal interests and preferences. For example, in our community project with reading volunteers, the child mentioned she likes spiders and the volunteer selected a book about spiders for the reading session with the child. In adaptation, performance metrics of individual children are used in the iRead program to select the sequence and difficulty levels of specific reading challenges (Mavrikis et al., 2019).

From these examples we extracted abstract scenarios connected to different types of personalisation to prompt conversations with our interview participants.

PERSONALISATION AS VIEWED BY EDUCATIONAL PROFESSIONALS

To understand how and why personalisation is used to raise attainment and engage students in the use of technologies, we interviewed educational professionals. Using an interview protocol based on examples of customisation, individualisation and adaptation, we sought to clarify the benefits and limitations of personalisation. Our empirically-oriented research question was: What are the perspectives of designers and educators towards personalised instruction and personalised educational technologies? Our second, more conceptual, research question was: How can we integrate the perspectives of educational professionals with the research on personalisation to create a framework to guide future research and design?

Methods

The creation of our framework relied on three levels of analysis: 1, a conceptual analysis based on a literature review, 2, an integral evaluation of our own work in the area of personalised educational technology and 3, empirical analysis based on interview data. The conceptual and integral evaluation parts relied on a traditional concept analysis, which includes reflection, discussion and interpretation of scholarly literature (Jackson, 1998). The integral evaluation consisted of merging all interview data into one shared file that we jointly analysed and interpreted by grouping similar attributes. We selected participants' quotes that capture the essence of the emergent categories and demonstrate the relevance of the

interview data to the final framework. Our conceptual analysis included an attempt to explain complex phenomena in light of existing theories and studies, enriched by discussions among the authors, our participants and re-reading of relevant literature including the interrelationships of the three main concepts—customisation, individualisation and adaptation—connected to the term 'personalisation'.

The empirical part of this paper relied on interview data and a post-interview discussion with educational professionals. This part is described in more detail in the following section.

Participants

Our convenience sample consisted of four teachers working in pre- and primary education and six designers of personalised instruction. More specifically, this included three middle-school teachers and three designers of web-based technologies from USA, California; one designer of web-based resources from the UK; two designers of children's apps from the Netherlands and Sweden; and one Norwegian kindergarten teacher. We selected these participants because they were familiar with personalised education or personalised design. All participants were personally known to the researchers prior to the study. We opted for this convenience sample because we wanted to have the perspectives from professionals with a direct experience of personalised design, and because we assumed that through a previous rapport with us, our participants will share their insights openly and in detail. The US participants had experience of working with personalised resources in the context of middle school and formal learning, while the European participants had experience with younger children and technologies designed for entertainment and the home context. As such, the sample covered the K–12 age range and both formal and informal learning environments. We approached the participants directly via email or telephone, explained the purpose of the study and invited them for a face-to-face or telephone interview.

Interview procedure

We opted for semi-structured interviews as they afford greater breadth and depth of information than surveys or highly structured interviews (King et al., 2018). To conduct our interviews, we defined personalised design and instruction as education that offers support, progression pathways and selection of content that can be tailored automatically or directly to individual users. With this definition, we explored how designers and educators who work with educational technologies conceive of personalised design and instruction, how they use it in their work and what pressing questions they see in the field. We focused on the participants' *perspectives*, which is an umbrella term to capture participants' views, attitudes and ideas (Hammersley, 2012). We followed a participatory educational research approach that honours participants' prior knowledge and provides access to new knowledge as it emerges through discussion (Bishop, 1997; Grundy et al., 2003).

The interviews were in English, they followed an interview protocol (see Appendix), with questions established a priori by the research team. The interviews were conducted between a participant and either Kucirkova or Gerard, on a one-to-one basis, lasting maximum an hour per interview. There was no difference in the interview protocol regarding interviews with the teachers or designers. The participants were next asked to define what counts as personalisation in relation to four scenarios. These scenarios were chosen based on our own work in this area, with the intention to prompt discussion around diverse and commonly experienced uses of personalisation in educational technology. Scenario A and Scenario C were supported with a screenshot of a real software program to illustrate the

type of personalisation (see Appendix). Scenario A concerned assigning alternative forms of a critique activity depending on the students' prior performance in the unit. Scenario B concerned e-books, recommending book titles based on child's reading interests/history, similar to Amazon's book recommendation based on users' book selection history. Scenario C offered students a choice between two investigations they could conduct using an interactive, scientific computer model. Scenario D concerned providing children with possibilities for adding their own content (their own audio-recordings, text or drawings) to a book they are reading.

During the interviews, the researchers took hand-written or typed notes. After the interview, these notes were shared with the participants who were invited to check the transcript and edit if anything did not accord with their perspectives. The anonymous edited transcripts were analysed for emergent themes. The study was approved by the Norwegian Centre for Research Data. The participants were free to withdraw from the study at any time and were invited to comment on our interpretation of their perspectives during and after the interview. We emphasised to the participants, throughout the process, that there are no right or wrong answers and that we are interested in their honest opinions. We positioned ourselves as collaborators, who share with the participants the 'community of practice' (cf. Duguid, 2012) of personalised education, aiming to arrive at shared understandings that can inspire other educational professionals. The final article was shared with interested participants before peer-review, but no changes were made. The study findings were discussed with a selected sub-sample of three participants who responded to our follow-up email invitation to reflect on the final Framework together with us, the authors. These three participants were two European designers and one teacher, and their views are incorporated into the Discussion section.

Analysis procedure

Our analysis followed four stages. First, we analysed the participants' reactions to the four scenarios. These provided an insight into the participants' perspectives towards the different levels, or degrees, of personalisation. Second, we analysed the features of personalisation, based on participants' own examples of personalised instruction or design. The third stage focused on the main themes in the participants' responses to the interview questions, which we categorised according to opportunities and trade-offs of personalisation. In identifying the main themes, we focused on their surface semantic meanings rather than the frequency or linguistic nature of participants' narratives, as we sought to theorise the broader meanings of participants' words in relation to the literature (see Patton, 1990). In the fourth stage, we integrated the comments with the peer-reviewed literature as well as policy documents in US and UK that mention personalised education. We reflected on our own practice of researching and directly contributing to personalised design over the past ten years or so. This reflection exercise was guided by the second research question and our objectives to not only understand current practices, but to also provide an agenda and theoretical framework for future applications of personalisation in education.

Findings: Perspectives of educational professionals

This section integrates our conceptual and empirical analysis, presenting the results in relation to the key themes that we identified in the interviews with our participants. The findings provide a base for the Framework that we present in the Discussion section.

Degrees of personalisation: Context of personalisation

Context of personalisation plays a role, as identified in the participants' responses to the four scenarios. All participants perceived Scenarios B, C and D as representative of personalisation, but they were sceptical about Scenario A. The lack of choices and possibilities for adjusting the content in Scenario A were cited as the key reason why the participants thought it was not an example of personalisation. As a teacher participant noted:

> 'Just because you are getting different things doesn't mean it is personalised'.

In contrast, the option of receiving a book recommendation based on the user's prior choices in Scenario B was perceived as an example of personalisation. The choice of hot and cold in the thermal challenge in Scenario C was perceived as a personalised learning experience for eight out of the ten participants. Conversely, all participants agreed that Scenario D was about personalised learning because it enabled users to add their own content. One designer commented:

> This allows children to bring their own creativity to an activity. It is less responding to students and more towards the goal of encouraging self-discovery.

Thus, the more capacity and choices the students had to direct the personalisation, the more our participants perceived the students' experience as personalised. Correspondingly, the option of adding users' own content was perceived as most personalised and the scenario of one or no choice as least personalised. It was thus the intensity of adaptivity that determined the degree of personalisation, rather than its presence or absence. As the UK-based designer put it:

> You see, to me, personalization is a spectrum, it is not black-and-white. Some are more personalized than others.

Features of personalisation

The participants' own examples are especially telling about how they define personalisation. The participants provided diverse examples from their work, which we categorised to align with the literature review.

Customisation

For three of the interviewed designers, the possibility to support children's reading, creativity in play or learning more broadly was the key reason for using personalisation in design. A US teacher mentioned the possibility of personalised content facilitating students' knowledge integration. For the Dutch designer, the possibility to offer the same content in various languages as widely used in apps, was valued to support diverse children using them. The teachers thought of personalised learning as following a curriculum adjusted to individual students. A US middle school teacher reported:

> Personalization is giving kids content at a level that is appropriate for their current understanding level.

In addition, the US teachers mentioned the possibility to adjust the content of textbooks to their geographical area to make them more interesting to the students. These examples illustrate the view that existing resources need to be adjusted to the students' shared characteristics to count as personalised.

Individualisation

Individual choice was a feature of almost all examples provided by the participants around personalisation. Some teachers provided students with choices in a workshop or during the lesson, while the designers strived to incorporate choice into their design. A US curriculum designer highlighted one aspect of the equity/equality dilemma:

> So the reason for giving choice is so that students go deep in areas that are interesting to them. We recognize that they will all get something different out of the experience rather than learning certain standards. We want them to get something they are proud of, learn something they wanted to learn.

The balance between guidance and students' own choice was not always easy to achieve. In design, this translated into the tension between open-ended and template-based design. The Swedish designer made it clear that effective design needs both:

> I would say that kids need both open-ended and fixed experiences, one is not worse than the other. Variation and having both is important, not either/or. If you experience fixed stories you can bring it to the open-ended. We focused on the open-ended because that was lacking on the market, we wanted that children are not always guided.

Thus, our participants viewed students' control and power to choose as key to a learning experience defined as 'personalised'.

Adaptation

Participants discussed adaptation as a form of personalisation less frequently than the other categories, perhaps due to the nature of the scenarios and the experience of the designers we interviewed. A designer from the US defined personalisation as the possibility of adjusting the learning platforms to users' levels of ability. One of the US designers distinguished adaptation as follows:

> There are three ways to personalize instruction. Personal characteristics: the goal would be to provide content at a specific level (age based, for example) or content that addresses the student's personal characteristics or demographics. In the second instance, where students direct their investigation, that gets more at engagement and personal relevance. The third instance, automated scoring, is more trying to address gaps in knowledge that we might be able to identify or providing students with content that is appropriate to their needs.

Trade-offs in personalised design

The interview questions probed for detailed information in participants' perspectives of the trade-offs involved in personalisation including the positives and negatives of personalisation.

The choices in personalisation

The participants recognised the clear benefit of personalisation in that it offers more choice to users, students, and readers while also noting the trade-offs. Having a choice was perceived as motivating and affirming to the students' identities. As the Dutch designer explained, the benefit of personalising is closely linked to the nature of the personalisation:

> For me the key mechanism is to deeply engage children with the story. That is why you need to choose personalisation wisely. If you have too many things that children can personalise it becomes like a Christmas tree and overwhelming. You need to be clear about your goal and depending on that goal - creativity or language learning - you design for it.

One US teacher questioned the balance between technology-driven personalised education and teachers' own agency and choice in personalising the curriculum. To find the optimal balance between these opportunities and limitations of personalised technologies is a difficult task for designers and educators, as summarised by this US web-based curriculum designer:

> Since there are a wide variety of types of personalization, an interesting question that I have and we have started investigating is what is the best combination of personalization in the classroom. Finding a balance between them, given each approach has a different goal.

Financial and planning implications of personalisation

Personalised design has costs for designers and teachers. The designers mentioned the financial constraints connected to the need for creating multiple learning paths or several stories in a personalised reading experience. For the interviewed teachers, personalisation required more of their own time. The teachers mentioned the need to have new and ongoing information for being able to do personalisation effectively, as well as the need to manage multiple paths for individual students. One middle school teacher noted:

> It is very hard to manage, having different groups, have to be able to assess students throughout to determine what is appropriate for each group…You have to plan three times as many things as you would normally have to.

Privacy and personalisation

Both teachers and designers were concerned about privacy issues. They mentioned that asking for personal data such as number of siblings or vacation destination can make the students feel uncomfortable.

Pedagogy and personalisation

Educational professionals expressed the importance of connecting personalisation to pedagogy. One US teacher remarked:

> Is personalization a strategy or a philosophy? More specifically, how does it fit in with overall inquiry learning, knowledge integration?

The Norwegian teacher explained the need to link personalisation to its democratic goals by connecting it to appropriate pedagogy:

> The key limitation is about seeing all children as equal (…) when creating movies, we had different activities. We had children very engaged in the story creation, but when creating props other children became interested, and in the stage of animating with photos, all children were part of the activity, so the limitation happens if you offer a narrow pedagogy with only some activities. Then you will limit some children. But if you offer wide variety of activities then you can personalize it.

Other participants mentioned that many of the current "personalised" systems are personalised to some but not all children. This may make children feel alienated, particularly in relation to their cultural background, dominant language, or physical appearance. One curriculum designer wondered about ways to investigate the long-term implications and consequences of personalisation for individual students:

> Did it give her a sense of agency to explore her ideas, in other contexts? What are the long-term effects, longitudinal effects of personalized learning for students?

DISCUSSION: A RESEARCH AND DESIGN PERSONALISED INSTRUCTION FRAMEWORK

Our Framework is consistent with the empirical findings of the interviews and the conceptual issues they raise. It also reflects the key themes in our previous work and the literature surrounding personalised learning. The individual elements of the Framework are presented in a simplified form in Table 1 with direct applications for the research and design community and its conceptual element in Figure 1.

Our interviewees recognised personalisation as a spectrum with varying intensity of three types of personalisation: customisation, individualisation and adaptation. The ways in which they defined personalisation varied but there were three common strands in their responses, which related to the purpose of personalisation and the data used to adjust the content. The three types of personalisation draw on information *about* the students, *within* the students, or *from* the students. The agent for personalisation and the audience of the personalisation differ. Figure 1 includes *illustrative* examples of data used for the three types of personalisation and it specifies who collects and shares the data. The framework simplifies the process of choice-making by locating the choice in the learner, the teacher or the system. It should be borne in mind that in dialogical classrooms and with advanced educational technologies, the teacher or the system makes *suggestions for* learners' choices, rather than making the choices for them.

The three types of personalisation reflect the diverse conceptualisations of personalised education in the extant empirical and policy literature (see Introduction). Rather

TABLE 1 Guiding framework for personalised research, design and instruction in education

Type of personalisation	Paradox/Dilemma	Possible research questions	Design Decisions	Teachers'/implementation
Customised education [system supports the choice] Categorical data, eg, age, gender, test results, local context, prior performance	Group/Individual benefit	How are categorical data and instructional frameworks used to support customisation that benefits the class and what are the implications for subgroups?	How are student data and the instructional framework combined to benefit each student in the class?	To what extent are student' data used for biased decisions?
Individualized education: [individual makes the choice] Psychological data, eg, Choices, Preferences, Interests, Own content	Equity	How are participants' own choices supported and what are the implications?	How is support for student choice incorporated into the design, and how are students supported to distinguish among these choices?	How do I support students' choices in my instruction and don't disadvantage any students?
Adaptive education [system makes the choice] Data patterns, eg, Performance metrics, Repeated behaviours, AI scores	Validity of measurement	What are valid forms of measurement and student data to use in current and future research?	How do I use participants' data to inform responsive designs?	How does the algorithm account for students' colloquial language when they understand the content?

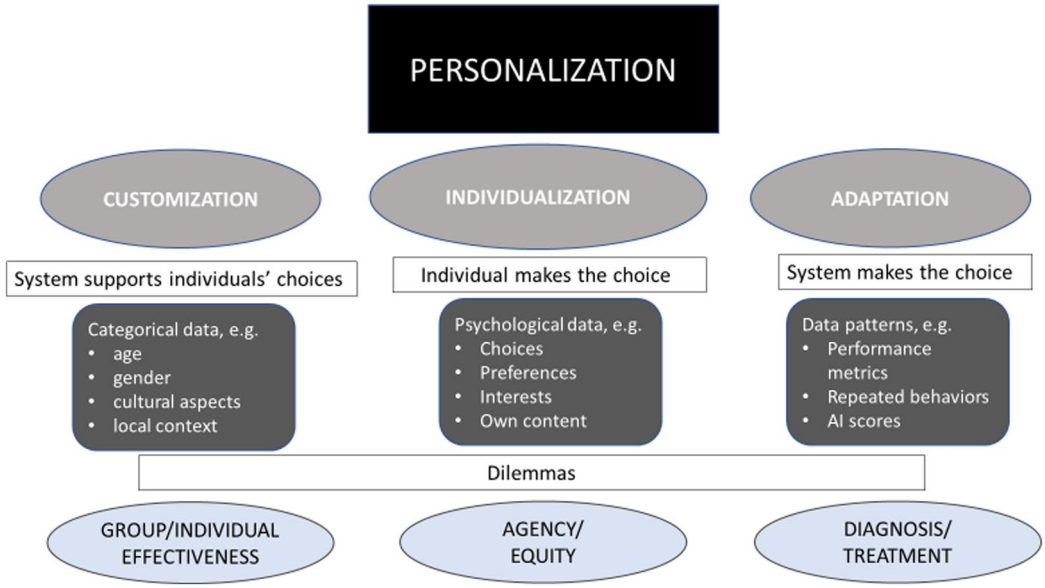


FIGURE 1 Schematic representation of personalised education

than perceiving them as separate and mutually exclusive descriptors, their co-existence in participants' discourse and our own work made us reflect on personalisation as an umbrella term for all three types. We refined our initial definition of personalised education to:

> Personalized education includes customized, individualized, and/or adaptive design. Decisions draw on categorical data (e.g., age, gender, location), psychological data (e.g., individual choices, preferences, needs) and/or data patterns (e.g., repeated behaviours, achieved scores).

Such a definition integrates understanding of personalised education in current literature, rather than viewing adaptive or customised education as separate from personalised education (cf. Chrysafiadi & Virvou, 2015; Sokolov, 2001). It invites judicial combinations of personalisation that might benefit diverse types of students. Striking an optimal balance between, for example, customised and adaptive education, maps onto some dilemmas. We identify three dilemmas that are important components of the Personalisation Framework, as they represent issues that can either support or hinder the adoption of personalisation in practice. The dilemmas are a synthesis of the trade-offs and competing interests identified in the literature and participants' perspectives.

Dilemmas in personalisation

Three dilemmas in the implementation of personalised education were clarified in the comments of respondents, our own work and prior literature. We structure the dilemmas in light of the key examples and previous studies of personalisation that we outlined in the Introduction.

Customisation and the group/individual effectiveness

The first dilemma concerns the imperative to reach each student, while supporting the learning of the group in the classroom. As noted in King Chen et al. (2020) and by the interview participants, there are tensions between teachers' agency in customising the curriculum with group-level data, while keeping it effective for each individual learner. Robust frameworks for supporting teachers' choices in curriculum customisation and learners' choices in customising their own learning, are emerging (Penuel & Lawrence, 2009). As shown in Figure 2, a teacher customised the WISE Thermodynamics Challenge to add an activity in which students create a diagram of heat flow after she observed how her students were challenged to interpret the flow of thermal energy within the virtual experiment students used in the unit. She chose a diagram recognising that while drawing could benefit all students, it would in particular reduce the language demands for students who do not speak English at home.

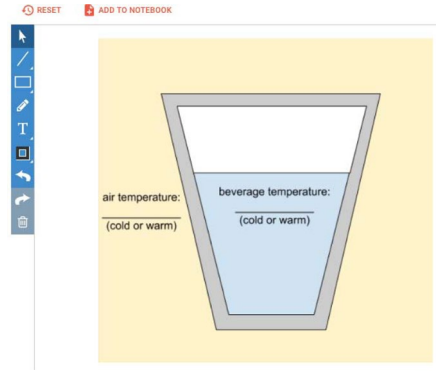
These decisions might benefit from sharing of personal data in a secure and ethical manner, raising awareness of the need for collaboration concerning data privacy and curriculum design and implementation (Awad & Krishnan, 2006). In relation to reading, we have observed the challenge teachers face when they try to adjust reading recommendations to children's individual cultural background or mother tongue, while ensuring the child makes adequate progress according to the curriculum (see Kucirkova, 2017). This issue was commented on by our participants, as noted in the sub-themes Pedagogy and Privacy in Personalisation.

a) Individualized: Student Choice

Students choose which investigation they would like to conduct in order to help a company determine which type of cup to purchase. Students are branched based on their choice. Both branches are designed to provide students equal opportunities for learning thermal energy concepts.

b) Customized: Teacher refinement

A teacher customized the Thermodynamics Challenge unit by adding a drawing activity to support students to think about direction and rate of heat energy movement, a topic they explored earlier in a virtual experiment.



Use the drawing tools to show what you think is happening in the simulation. You can replay the simulation by clicking the "play" button.
Consider *factors that determine the direction of the heat energy movement* and *factors that affect the rate of heat transfer*

- Circle the word describing the temperature of each component of the system.
- Add arrows to show the direction of heat transfer.

FIGURE 2 Individualization, customisation and adaptivity in the WISE thermodynamics challenge

Individualised learning and agency/equity

In individualised learning an equity dilemma concerns ensuring that individual, micro-level choices are genuinely empowering for each individual. Described as ‘a critical goal and challenge in modern education’ (Clabaugh et al., 2015, p.26), personalised education has been appropriated politically in the past decade to symbolise concern for equality, democracy, and success for each individual in the society. The desire to personalise education to each individual child is not new (see Dewey, 1902); achieving the ideal of equitable, personalised education requires financial and personnel resources along with innovative designs. For choice to be an empowering tool, it needs to be individualised not only in terms of its fit with the individual's needs but also with the societal implications. The issue was brought up by our interviewees, particularly those from the design community who commented on the difficult issue of equitable choices in personalisation.

We propose that the most ethical way of individualising choices is by giving the ownership and control to the individual, that is supporting individual agency not only at the choice stage, but also prior to the selection of the choice. How to suitably adjust students’ agency to the choices available to them within a broader educational system, is an open question for the field and for the professional practice of personalised education. Many hope that this challenge will benefit from data-based technologies (eg, Walkington, 2013). In our own work, web-based inquiries are individualized by providing students the opportunity to make choices about how to direct their learning. This may occur in the form of what investigation to pursue among a given set of options (Figure 2), or what type of guidance would be most helpful for them to revise their explanations. In reading for pleasure, children's needs and preferences are taken into account with open-ended story-making apps, where children can create their own stories, but without appropriate scaffolding mechanisms, not all children can leverage these creative possibilities to the same extent (Kucirkova & Littleton, 2017).

Adaptation and validity of measurement

A dilemma concerning adaptation is the validity of the measurement of what students did in the past and where they might be directed. As noted in relation to pedagogy and personalisation in our interviews, there are ethical questions concerning the overall purpose of collecting personal data and adapting instruction if there is no suitable support. Recommender algorithms embedded in educational software programs collect students’ data, and tailor the pace or sequence of the learning content (Natriello, 2013). As pointed out by our participants, these metrics do not always push the learner in the most advantageous direction. The benefits of adaptation may be enhanced when users are aware of the measurement used to assign the adaptive treatment (Tansomboon et al., 2017), consistent with the interviewees’ belief that scenario A was the least personalised. In medical terms, this is referred to as the mismatch between cure and treatment (Nordenfelt & Lindahl, 2012).

In commercially-produced reading programs, the system makes a choice on behalf of the child, based on the child's interaction with the software, such as, for example, with the DinoTale app, that was analysed in terms of its potential to both support child's interest and motivation to read but also stealth assessments that might not necessarily align with children's actual needs (Kucirkova & Mackey, 2020). Similarly, the WISE platform embeds the natural language processing (NLP) tool craterML™ in web-based inquiry projects to automatically score student written explanations and assign adaptive guidance. Explanations are scored using a knowledge integration rubric measuring the links among ideas. The NLP models have demonstrated good agreement with expert human scorers and a lack of bias across subgroups of gender, language background

and prior computer use (Gerard & Linn, 2016). Guidance is assigned to the student instantaneously based on the craterML score and is designed to help students move up one level in the knowledge integration rubric, as shown in Figure 2(c). The guidance is iteratively refined by a partnership of researchers and teachers to ensure the guidance is both responsive to the student's reasoning and encourages the student to take ownership for revising (Tansomboon et al., 2017). The dilemma highlights the need for greater collaboration between designers and educational professionals to establish synergies between students' needs and curriculum opportunities. It requires a systemic coordinated approach to work in learners' best interests.

These three dilemmas of individualisation and equity, group customisation and individual benefit, and adaptation and validity of measurement might explain why it is difficult to scale up personalisation (Greene, 2018). They might also help explain why personalisation has been historically met with both enthusiastic responses and strong resistance among educational professionals (Keefe & Jenkins, 2000). Recognising the benefits and limitations of personalised design, we suggest that future personalised education needs to directly address the dilemmas to fulfil its promise for children's learning. To facilitate this process, we propose some questions for researchers, designers and instructors/teachers that can guide their own understanding and practice within the spectrum of customisation, individualisation and adaptation in education (see Table 1). Our guiding questions are deliberately phrased as open questions to invite reflection and conversation. We encourage researchers, designers and teachers to consider their stance on personalisation using the lens of the three personalisation dilemmas.

Study limitations

This study was conceptual and sought to stimulate dialogue in the research and design community of educational technology regarding personalisation. The empirical part relies on interviews with a limited number of participants who were all known to us before the study. While this sampling strategy allowed us to enter into deep and subject-relevant conversations based on mutual trust with experts on personalised learning, it did not provide us with a reliably representative sample. The empirical insights are therefore limited. We acknowledge the limited generalisability of our findings and couch the Findings and Discussion sections in tentative language.

The framework contains themes based on literature that we reviewed for the purpose of this study and it builds on extensive reviews of literature conducted on personalised learning by FitzGerald et al. (2018); Shemshack and Spector (2020) and Tetzlaff et al. (2020). Our aim was to integrate insights that provide an indication of likely perspectives of practitioners working with personalised learning and that indicate priority areas for a framework that can be usefully applied both in research and design of personalised instruction. We also aimed to provide an integrated perspective on personalisation that would acknowledge the dual nature of personalisation, as a force that might support but also disadvantage certain groups of learners. We do not perceive the framework as exhaustive but it is informed by theory and practice, and it includes both enhancing and limiting aspects of personalisation. It could be further refined by expansion of individual elements, including its application to learners with learning disabilities. The framework intends to move away from the linear language of data use in personalised education (see Williamson, 2019) to a more holistic view on personalised education. We offer the framework as a thinking tool for the field, with the hope it will stimulate discussion among colleagues and further refinement in future studies.

Future directions

Our findings draw attention to three dilemmas that are experienced by educators and designers who work with personalised curricula and technologies. They raise an agency paradox between each stakeholder including teachers, designers and students (Kucirkova et al., 2020). The agency paradox refers to the tension in personalised education that arises through the daily lived experience of subjective and collective agency in educational practice. For example, teachers want to support children's individual decision-making and choices, but they also need to narrow down student choices to suit the values and educational goals promoted by a shared curriculum. The agency paradox is likely to become more pronounced in future iterations of personalised design and instruction, as the decision-making is performed not only by human but also non-human actors such as artificially intelligent robots (AI), which support both individual and collective agency. Such an AI-mediated personalised education has implications for each of the dilemmas that emerged. AI-mediated personalised education is already available on the educational market in the form of intelligent tutoring systems that customise, adapt and individualise automatically. The design of these systems is not free from biases and, in some cases, personalisation may disadvantage rather than support certain groups of learners. Williamson (2017) has called attention to the ways in which the use of data in education reproduces or even enacts racial and socio-economic inequality.

Personalisation has implications for equity and inclusion and the policy issues raised by participants include the need to pay careful attention to cultural and privacy issues if personalisation is used as a strategy for future education. The literature and our work also underscore the importance of careful evaluation of personalisation with attention to unintended consequences as well as benefits for learners and their teachers or mentors.

Conclusion

We found that participants' perspectives, literature insights and key policy concerns about personalised education reveal three dilemmas that map onto three types of personalisation: customisation, individualisation and adaptation in learning. We encourage designers to try our framework and suggested research, design and practice-related questions to progress the field. The framework draws on an interdisciplinary literature base, our extensive work in the area and interview data with selected professionals familiar with personalised educational technology. The framework approaches personalisation as both a positive and negative force in education, acknowledging extant opportunities and dilemmas in current practice. With our suggestion of guiding questions for future research and design, we encourage future developments in personalised education research and practice and the professionals' capacity to address the dilemmas that emerged. As technology becomes more sophisticated and analyses of learner capabilities become more nuanced, the opportunities for personalisation increase, and so should our capacity to articulate and critically engage with them.

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CONFLICT OF INTEREST

We do not perceive any direct conflict of interest. We make it clear in the manuscript that our participants included designers of personalised educational technologies for children and that their perspectives were influenced by their professional experience. This close connection to practice gives our data authenticity and commercial insights but it might also restrict their generalisability across other kinds of technologies and personalised products.

ETHICS STATEMENT

The study received ethical approval from The Norwegian Centre for Research Data (Norsk senter for forsknings data) in 2019, according to which the participants had the right to transparency (art. 12), information (art. 13), access (art. 15), rectification (art. 16), erasure (art. 17), restriction of processing (art. 18), notification (art. 19) and data portability (art. 20). All data were anonymised and stored on password protected researchers' machines. We informed all participants about the study in a Participant Letter (email) and verbally before the interview and before they signed the consent form. We shared the transcripts with the participants so that they can correct any quotes they disagree with. Some participants requested to view the final article and we sent the manuscript for their comments before finalising it for the journal. Throughout the process of data collection, we treated the participants as research collaborators who are, together with us, part of a professional community interested in issues of personalisation and children's technologies, and who, together with us, academic researchers, carry the responsibility for modelling ethical processes in children's design.

DATA AVAILABILITY STATEMENT

Full interview transcripts are available upon request by contacting the corresponding author.

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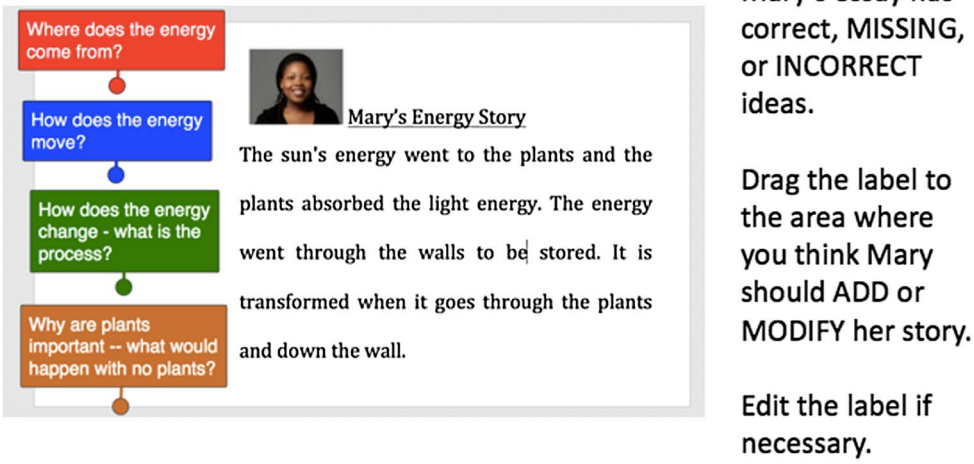
APPENDIX

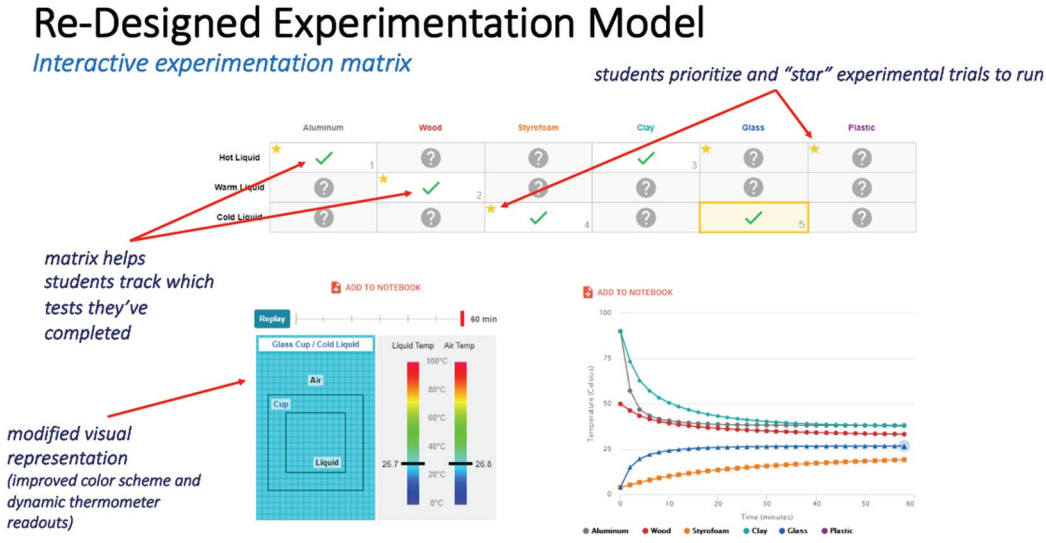
The four scenarios were as follows:

Scenario A: Students get a different version of the Web-based Inquiry Science Environment (WISE) annotator depending on their explanation score based on Natural Language Processing analysis by c-rater.



Scenario B: In e-books: recommending book titles based on child's reading interests/history. Rather like when Amazon recommends a book for the user based on their book selection history.

Scenario C: Choice in the Thermal Challenge: Choose to investigate either cups to keep a hot beverage hot or a cold beverage cold. Record your experiments and test with this model.



Scenario D: Providing children with possibilities for adding their own content (their own audio-recordings, text or drawings) to a book they are reading.

Interview protocol

Interview questions

What is personalisation in your field?
What does personalisation mean to you?
Can you give an example of personalisation from your work?
What is the goal of using personalisation in your work?
What information do you use to personalize instruction or design?
What are the main advantages and main limitations of personalisation?
What is the mechanism/goal of personalisation?
What are open questions that you would like answered about personalisation?
What questions would make sense for a research agenda in personalised learning?